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Synecology of *Collembola*

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ABSTRACT. A short review of synecological research of *Collembola* is presented. Three levels of synecology are distinguished: 1. faunistic, 2. simple coenotical approach, and 3. computer aided coenotical analyses. Methodological problems of collembolan community studies are discussed. Sampling and extraction techniques could introduce serious errors concerning quantity and quality of the primary data. The intense development of collembolan taxonomy during the last three decades has caused problems with species identification for students not familiar with taxonomy; since 1960, in Europe the species number has tripled. This problem could be solved by cooperation of ecologists with taxonomists and by publishing comprehensive identification keys for *Collembola*.

INTRODUCTION

Synecology is a branch of ecology dealing with organisms on the community level and with the relation of communities to abiotic and biotic factors (HENTSCHEL, WAGNER 1986). *Collembola* are a suitable subject for synecological studies and their communities have been extensively studied since the 1930s. Many collembologists have contributed significantly to animal synecology and have developed its general methodology and terminology.

Parameters of soil animal communities are important for ecosystem and environmental studies. They may signal environmental changes in advance of other parameters, e.g. plant cover. Collembolan com-

munities are very sensitive to environmental stressors (RUSEK 1993). It is a pity that synecological studies of *Collembola* are rarely a part of important international ecological research programmes.

Historically, many contributions to synecology of *Collembola* have not been of great value and many authors still produce, for different reasons, contributions of low quality. The goals of this contribution are to show the weak aspects of such studies and to evoke discussion that would help to improve the current situation.

HISTORICAL SURVEY

Reliable studies of *Collembola* on the community level have began relatively late, as in almost all other groups of small terrestrial animals. KSENEMAN (1938) was one of the pioneers of community studies in *Collembola*. He was influenced by plant sociologists and he applied and modified in his studies their methodological approach, as well as many plant ecological terms. GISIN was strongly influenced by KSENEMAN's contribution and he further developed the synecology of *Collembola*. In GISIN's (1943) "Ökologie und Lebensgemeinschaften der Collembolen im schweizerischen Exkursionsgebiet Basel", eco-morphological groups of *Collembola* were introduced and the main coenological units, so called "synusies", were described. However, he did not follow the plant sociological taxonomy in classifying collembolan synusies into basic and higher units and giving them taxonomical names. This was an important approach to collembolan community studies, leaving the community "taxonomy for taxonomy". Now we may appreciate this informal direction in soil animal sociology, which uses the coenotical parameters for characterizing and explaining the community structure and its changes. GISIN contributed not only to the knowledge of collembolan communities, but also to a general "biocoenotical" synthesis (GISIN 1944, 1946, 1947, 1948).

The predecessors and contemporaries of KSENEMAN and GISIN worked with collembolan communities on a "faunistic level" only. Their primary "quantitative" data were not exact and were burdened with methodological problems (e.g. sampling and extraction efficiency). Some collembologists are still working on this first level of synecology.

The second level, or simple coenotical approach, is represented by the already mentioned classical studies of GISIN and KSENEMAN and followed by most of their younger contemporary colleagues, e.g. CASSAGNAU (1961), DUNGER (1968), NOSEK (1969). Nevertheless, almost all of us dealing with collembolan communities started with the first or the second level of coenological research and are gradually entering the third level, i.e. computer aided coenotical analyses.

Many different computer programmes have been developed to analyse and classify the primary field data, e.g. HILL (1973, 1979), HILL and GAUCH (1980), ORLÓCI (1978), TER BRAAK (1987). These programmes enable us to classify communities, and some of them also allow us to analyse communities in relation to variable environmental parameters. These computer programmes are useful tools for analysing community data and their changes in short-term field experiments, as well as over a longer period of succession or the environmental changes effected by different stressors (SETÄLÄ and MARSHALL 1994).

During the last two decades many contributions dealing with collembolan communities, their changes in time or their dependence on certain environmental factors were published. PONGE (1973, 1980) analysed population changes of microarthropods over a time period, and the relation of forest collembolan communities to different abiotic factors (as e.g. soil properties, plant cover, etc.). He also showed that collembolan communities are good indicators of humus forms (Ponge 1983). An extensive primary material of collembolan communities from a forest-grassland landscape complex in France was analysed by multivariate correspondence analysis by the same author (PONGE 1993). POZO (1986) studied factors influencing collembolan populations, and SOUSA and DA GAMA (1994) used coenotical analysis of forest collembolan communities in connection with different forestry practices. RUSEK (1984) used ordination and different types of cluster analyses to classify collembolan communities in three types of periodically inundated meadows and their changes over time. This analysis distinguished successive changes from disruptions caused by inundations or dry periods. STERZYŃSKA (1990) used ordination and cluster analyses to classify collembolan communities in different linden-oak-hornbeam sites in Poland. These examples illustrate the usefulness of collembolan communities in studying ecosystem and environmental changes.

METHODOLOGICAL PROBLEMS

Community research of *Collembola* is developing progressively, but the results could be negatively influenced by many factors. The main sources of errors and inaccuracies are connected with sampling and extraction methods, species determination or taxonomical knowledge of the investigator.

Sampling and extraction methods. There are many manuals of soil zoological methods describing different techniques for soil sampling and extraction of microarthropods, e.g. BALOGH (1958), DUNGER and FIEDLER (1989), PHILIPPSON (1970). When conducting long-term ecological research (succession, global change, etc.), it is necessary

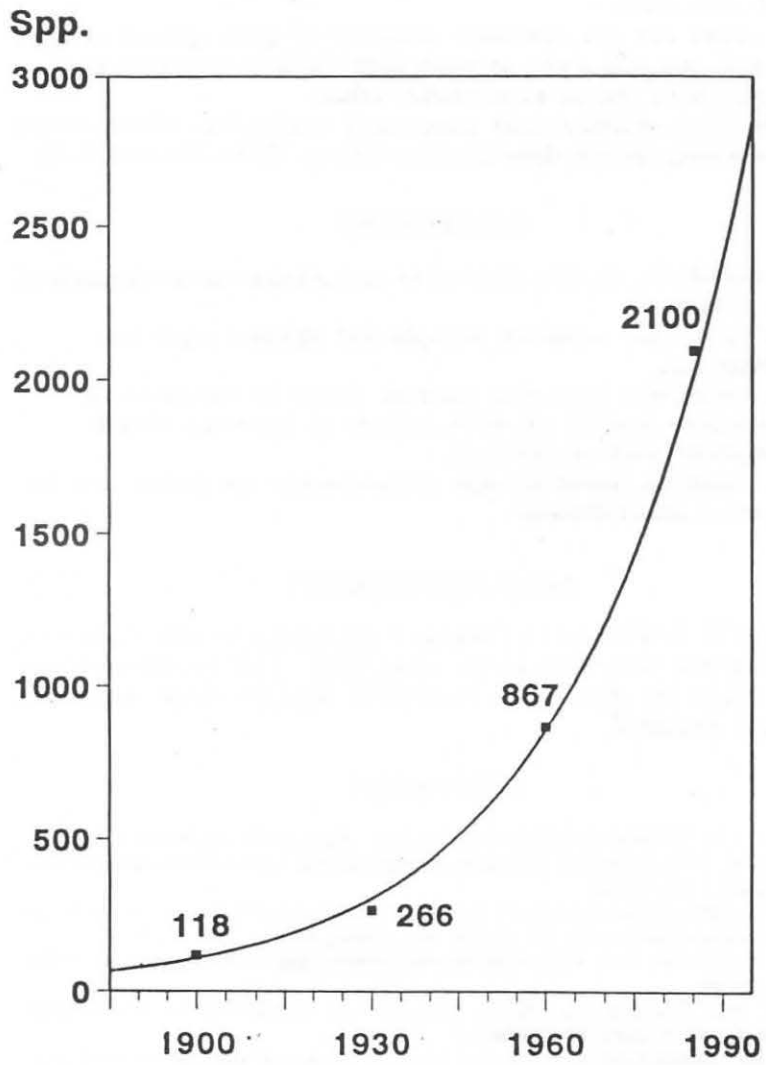
to use the same methodology (sampling and extraction technique) which allows for a comparison of data sets over time. It is common in soil zoology to work with abundance data obtained for a given soil surface unit. But occasionally some workers take samples by volume or even by mass units without giving the soil surface area, which could even vary. Such samples are sources of great error in getting comparable abundance data. The mode of transportation into the laboratory may cause abundance inaccuracies, too, if they are not protected against higher temperature or if they are mechanically damaged (shaking, pressed, etc.). A long storage before extraction influences the number of extracted animals as well. There is a need for basic standardization of sampling and extraction techniques for community studies of *Collembola*.

It is known that high-gradient equipment have the highest extraction efficiency (MARSHALL 1972). But when the thermo-hygric extraction regime reached the highest value too fast, the results could be negatively influenced. A good indicator of high efficient extraction is the presence of weakly sclerotized 1st instar larvae of euedaphic *Collembola* or the representatives of *Pauropoda* in the extracted material.

Some low density data published for *Collembola* from grassland and forest habitats by some authors could be explained by extractor inefficiency or sample damage.

SPECIES DETERMINATION AND TAXONOMICAL KNOWLEDGE

Soil zoology is a young science and the taxonomy development of most groups of soil fauna, especially meso- and micro-fauna, started in the first decades of this century. The state of collembolan taxonomy is illustrated in Fig. 1. At the beginning of this century 118 species of *Collembola* were known from Europe. During the next 30 years, 148 species were added to them, and in 1960 GISIN's "Collembolenfauna Europas" comprised 867 species. Twenty-five years later, in 1985, my file contained 2100 species and now more than 2700 collembolan species are known from Europe. Since 1960 the number tripled in the faunistically best known continent! Ecologists without active knowledge of collembolan taxonomy could not work in synecology of this group without assistance of taxonomists. A cooperation of ecologists with taxonomists is not rare and it is a good solution to the scarcity of comprehensive up-to-date taxonomic literature. The best is when a taxonomist also works in synecology. Unfortunately, there are still many cases where contributions of very low scientific value have been



1. The development of collembolan taxonomy in Europe since 1900. Spp.- number of species known in Europe in 1900, 1930, 1960 and 1985

produced because of wrong species determination. Species lists in these publications showed that many authors were not familiar with taxonomy and that they have used old GISIN's or STACH's keys (GISIN 1960, STACH 1955).

To count out the specimen numbers of each species is time consuming, and it is a pity so much time has been wasted to produce even books with almost no scientific value!

Sophistical mathematical community evaluations alone cannot improve wrong species determination (cf.e.g. TODA, TANNO 1983).

CONCLUSIONS

To improve the current situation in collembolan community studies, it is necessary:

- to use proper sampling methods and efficient extraction techniques,
- sampling and extraction methods should be standardized,
- ecologists who do not work actively in taxonomy should cooperate with taxonomists,
- taxonomists should publish comprehensive up-to-date keys for species determination.

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